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BACKGROUND OF USSR WORK ON INFORMATION ON PETROLEUM:

[Comment: The following is a review of an article entitled "The
Origins of Petroleum," which appeared as a November 1954 publication
of the French Institute of Fuel and Energy. The article, by P. M.
Edmond Schmitz, ex-Director of Petroleum Refineries and former in-
structor at the National Advanced School of Petroleum at Strasbourg,
is a reprint from Flamme et Thermique, No 68, 70, 71, 72 (May, July,
August, September), 1954.

In this review, an attempt has been made to select references to
USSR work and to outline this work in some detail both from the stand-
point of current developments and background information. Results of
work of this type are of importance because practical procedures
applied presently in petroleum prospecting, or capable of being used
in such prospecting, are based on them. An example is the current
USSR effort to develop microbiological procedures for petroleum
prospecting and the possible use of such procedures in the USSR.

Numbers in parentheses refer to the author's bibliography
appended.]

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To provide a basis upon which the reader may formulate an opinion concerning the origin of petroleum, the author has compiled information on the historical background of theories supported by experimental data collected from the beginning of the 19th Century to the present day.

Theories Prior to 1930

The theories appearing before 1930 were divided into three groups -- the cosmic, the synthetic, and the analytic, of which brief resumes are presented below. The only references cited in the bibliography are the Russian; all other references have been omitted.

1. Cosmic Origin

The basic supposition of this hypothesis is that petroleum and water once formed a part of the atmosphere, that they become condensed and subsequently precipitated onto the earth, infiltrating it and appearing later as petroleum or, in a solidified form, as coal. There were several adherents to the theory that petroleum was the primary product resulting from the combination of carbon and hydrogen by "cosmic" processes, the hydrocarbons remaining dissolved in the liqued magma until sufficient cooling occurred. A further modification stated that water would act upon certain heavy-metal carbides, giving rise to acetylene, which by polymerization and other reactions would be transformed into all sorts of hydrocarbons.

2. Synthetic Origin

A number of scientists, among them the Russian Lenz (1831) advanced theories of volcanic origin which assume that petroleum (or bitumen) is the product of a synthesis and a distillation effected at great depths; the products supposedly escape under the influence of a volcanic disturbance in the primitive rocks. (1)

The inorganic-synthetic theory of Mendeleev (1877) supported the idea that petroleum is of a purely inorganic origin, arising from the action of water on metal carbides in the very deep regions of the earth. (2) This hypothesis had several partisans, among whom was the Russian geologist Abich,

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who observed in 1879 that accumulations of petroleum were encountered most frequently along the anticlinal axes toward which the upheaved rocks converge. (3) The presence of metals in the asphaltenes seemed to be explained by Mendeleev's theory.

3. Analytic or Organic Origin

This category can be subdivided into three parts, all of which attribute to petroleum an organic origin, either animal, vegetable, or a combination of both. The decomposition of plant and animal life which has been distributed over the earth by various means, and its subsequent condensation at high temperatures and under high pressures, form the basis of most of these theories. The Russian scientist Andrussov (4) and others, pursuing previous studies along these lines, observed a surprising accumulation of cadavers of marine fauna brought into the fresh-water gulf of Kara-Boghaz by salt water from the Caspian Sea. They assumed that organic matter of this type may give rise to petroleum deposits.

A significant group of these theories propose that there exist certain bacteria whose vital activity results in the formation of bitumens. Living bacteria have been discovered in the waters of Russian and American petroleum beds.

Theories After 1930

The author considers the data published after 1930 as modern interpretations. The theories advanced during the past 25 years deal very little with the substance, apparently organic, which gave rise to petroleum, but rather with the formation of the raw material and with the possible processes by which it was transformed into petroleum. The author groups these new studies into the following three classes:

1. Source

Most works on this subject concern possible relationships between depth and the nature of deposits, the different pressures and temperatures at these depths considered as influencing the properties of the deposits. Some scientists thought that the young beds arose from the old, and that the depth of the organic deposits was a determining factor. Other proposed relationships pertaining to age and depth specified that variations cannot necessarily be attributed to differences in the depth of beds, but probably to physical causes operative in the reservoir rocks.

Modifications of these theories differ with regard to the effects ascribed to temperatures at specific depths, catalytic action, formation of secondary reservoirs, and the influence of geological age. Frust [Frast?] and Minovskaya investigated the role of catalysts (5,6); Obryadchikov studied temperature conditions. (7) The conclusions of the Russian scientists in general was that certain types of petroleum were formed at temperatures below or equal to 150°, while others, as evidenced by their chemical composition, were produced between 150° and 250°.

2. Chemical Composition

The most significant event from the chemical point of view was the discovery of chlorophyll porphyrines in bitumens, petroleum, and combustible shales; their presence supported the vegetable-organic theories. It was suggested on the basis of subsequent experiments that microorganisms act on the organic matter, giving rise to carbohydrates, proteins, fats, and a "proto-petroleum" of undetermined character, this "proto-petroleum" is then transformed into petroleum by catalysis, isomerization, and cyclization.

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3. Transformation of the Organic Material

In conjunction with the physical factors of temperature and pressure, agents such as catalysts, bacteria, and radioactivity have been assumed to play an important part in the formation of petroleum.

a. Catalytic Action

Various catalytic agents figure in reactions of hydrogenation. The participation in petroleum formation of hydrogen derived from hydrogen sulfide may perhaps be assumed. Khmelevskaya (1947) postulated on the one hand the formation of hydrogen by the action of water vapor on natural compounds of iron at 700-800°, and on the other hand a hydrogenation at a depth where the temperature is around 300° and the pressure is high. (8)

A "carbonium ion" reaction, in which catalysts play a large part, was postulated to explain the formation of unsaturated aromatics.

b. Bacteriology

Omelyanskiy stated on the basis of work done during 1895-1900 that selective fermentation occurs which yields in the case of cellulose either hydrogen or methane. (9) Bacteria were discovered in the petroleum beds of the Caucasus and in the black silt of the Caspian Sea and the Black Sea, after which it was decided to demonstrate the specific action of the bacteria present in the organic matter and figuring in the fermentation. Further research was directed at answering questions as to the limits within which the presence of bacteria is directly or indirectly linked to the formation of petroleum and at which point their action is exerted, what species of bacteria figure in this process, and under what conditions these bacteria can exist and exert an influence.

The author concludes that a double action, catalytic and bacterial, transforms the organic residue into a primary substance which is decomposed; the products of this decomposition are then subjected to general catalytic action, finally being converted into petroleum. The petroleum does not migrate, but is formed at the different levels where it is found.

c. Radioactivity

The radioactive properties of petroleum, sediments, and water were the object of research from the beginning of the 20th Century. Khlopin, Vernadskiy, and Bobin (1933) found that the water directly below petroleum beds has a radon content much higher than that of other subsoil water. (10) Numerous investigations showed that sedimentary rocks have an appreciable content of radioelements.

It was demonstrated that the molecules of a large number of organic substances can be broken down into simple hydrocarbons and nitrogen by alpha bombardment; products of this transformation are converted, under continued bombardment by alpha particles, into hydrocarbons with higher molecular weights and a different constitution. The final products are diverse liquid and solid hydrocarbons, and a gaseous mixture of secondary products which include hydrogen, nitrogen, methane, and helium. The helium is apparently derived from the alpha particles.

Conclusions

The author states that a clear, precise conclusion concerning the origin of petroleum cannot be formulated. In view of the various results and opinions on the subject, he assumes that the process of petroleum formation comprises:

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1. The accumulation of organic material in sediments
2. Transformation of this organic material into hydrocarbons and diverse organic compounds
3. Conversion of the latter into true petroleum

The fundamental reactions accomplishing the transformation of the organic material into petroleum can be:

1. Chemical reaction with the aid of multiple catalysts, and concurrent factors of temperature, pressure and time
2. Bacterial action
3. Radioactivity

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